

## Measuring sensory and marketing influences on consumers' choices among food and beverage product brands

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## Review

# Measuring Sensory and Marketing Influences on Consumers' Choices among Food and Beverage Product Brands

**David A. Booth**

**Food Quality and Nutritional Psychology Research Group,  
College of Life and Environmental Sciences,  
University of Birmingham, Edgbaston, Birmingham B15 2TT, U.K.**

## *Abstract*

Advance in food science depends on measuring the factors in human perception that influence eaters' activities with branded products. Assessed samples must include at least two levels of a sensed material characteristic (e.g. sucrose) or conceptual marketing attribute (e.g. "low fat"), minimally confounded by other features. Each feature needs to be measured for its effect on the individual's objective achievement of choosing among the samples for a familiar context of use. These influences interact, consciously and unconsciously. This theory of how a mind works has generated a wide range of scientifically illuminating and commercially practical examples, illustrated in this review.

*Keywords:* human performance; food perception; food choice; consumer behavior; sensory characteristics; marketing concepts; healthy eating.

## Measurement of a Food's Impact

The basic conditions for measuring the performance of an inanimate material, or of a plant or animal, are well understood by the scientists and engineers who do such work. The measurement of human performance on food has to meet the same requirements, even though shoppers and eaters have the additional complexities of acting with intentions and thinking in concepts. Yet established practice in sensory analysis and in market research has neglected this logic and science. As a result, the usual computer-based collection and analysis of data fail to support the measurement of influences on choices among foods. Existing systems could easily be modified to give precise and operational answers.

The fundamental requirements of psychological food science are briefly summarised below. Then a variety of examples is given of the calibration of two or more factors in human perception and choice of a food.

### *Requirements for Any Measurement*

A potential influence can only be investigated if it varies independently from all other factors. Otherwise it is logically impossible to pick out its effects from others. This requirement has been disastrously misunderstood in some laboratory science that is meant to be practically relevant. It is assumed that the hypothetical factor has to be manipulated by the experimenter. Worse, traditional methods are founded on isolating the factor under investigation from all other reality. On the contrary, appropriate selection among existing samples can minimise correlations between influences. If that were not so, observational sciences could not exist. Indeed, the best experiments in food science simulate the conditions of consumption as closely as feasible. It may be necessary to make the required samples but all or some may already be on the market or have been prepared as new propositions for pilot testing.

The set of food samples to be tested must have at least two levels of any sensory or marketing factor to be investigated. To measure one influence, only two samples are needed, presented twice each. If two or more potential influences are to be investigated at the same time, then the lower and higher ranges of those influences have to be crossed with each other, i.e. varied orthogonally. It is not necessary to limit the lower and higher ranges to a single value each. Furthermore, correlations between the levels of two influences can be as high as  $r = 0.5$ . The confounding between the variances is still only 25% – in practice leaving a good chance of distinguishing the two effects on choice (Booth, Mobini, Earl and Wainwright 2003a).

This logically required design can be extended to any number of factors that potentially influence perception and choice, so long as the number of samples is greater than the number of influences (Figure 1, left-hand side). Only two levels of each factor are needed. The higher and lower levels may be ranges of values, because the analysis is by regression through the calibration line of raw data-pairs from individuals, not by differences in variance between group mean responses to fixed levels.

So long as both the highest and the lowest values of a factor are realistic to the food being investigated, wider ranges provide more sensitive measurement. Nevertheless, the two values that are absolutely necessary have only to be as far apart as is distinguishable by an assessor familiar with the food.

## DESIGN OF TEST FOODS AND RATINGS

Quantity of factor		Levels of factors 1 to 4 in tested samples A to H								Rated distance from ideal <i>I'd always choose this</i> <input type="checkbox"/>	Concepts of non-ideal <i>Too Too</i> <i>little much</i>
Range	Level	A	B	C	D	E	F	G	H		
Higher	Higher	1		2			3	4	1	<input type="checkbox"/>	.....
	Lower		2	1,3	3,4	4	2	1	3,4	<input type="checkbox"/>	.....
Lower	Higher	2	4		1	3,2	4	2	2	<input type="checkbox"/>	.....
	Lower	3,4	1,3	4	2	1	1	3		<input type="checkbox"/>	.....
										<i>I'd never choose this</i> <input type="checkbox"/>	
										(worse) <input type="checkbox"/>	

Figure 1. Example of design of food samples and quantitative responses that meet the minimum requirements for measuring the interacting influence of up to four sensed or symbolic influences on the recognition or acceptance of a branded or unbranded edible material by each member of a panel. The level of a factor in a food sample is a physicochemical or labelled quantity, either selected from existing items or newly created. The higher and lower levels within a range do not have to differ: the same quantity can be replicated. The samples with the highest and lowest levels must be tolerably acceptable. The sequence of presentation of samples is not critical but the highest level of each factor is best tested earlier in the series. “Always choose” should be scored 0 (no difference from ideal); “never choose” = (-)9. The (interpolated) ideal can be personally most preferred or an exact match to a familiar version. Samples should be designed never to be worse than just unacceptable. Verbal characterisation of effects stronger or weaker than wanted/expected should be avoided unless descriptive analysis is of interest. Those words can be each panellist’s choice or a consensus vocabulary of a previous panel from the same population.

## ***The Principle of the Peak Value***

Measurement of influences on choice has to allow for a basic principle from psychological science, in addition to the above general logic of separating influences from each other. A person decides how to act by comparing the situation with a standard or norm built up in memory from similar situations (Booth, under review; Booth and Freeman 1993; Booth, Thompson and Shahedian 1983; Conner *et al.* 1986). This personally learnt norm has a 'just right' value (ideal point) for each feature that has been relevant in the past. An item will have its strongest impact on action when each feature matches this level of the norm. If a feature in a test item is at a level either below or above the norm, the impact will be less. As a result, an overall response does not get stronger and stronger as the presented level of a feature gets higher and higher. The response reaches a peak at 'just right' and then decreases.

The immediate practical consequence of this peak principle is that an assessor's responses to test items should be anchored on that person's norm levels for their perceived features. Indeed, the data are not fully interpretable unless one of those anchors is a perfect match for the target of the investigation. This may be the leading brand, the assessor's usual product or the personally most preferred version.

Indeed, the fundamental psychological theory is that an exact match to the standard learnt from life is the primary category used in responding quantitatively to any layout, whether or not words equivalent to "just right" are used as an anchor point. In addition, it is a logical requirement for linear responding that there be only one other anchor phrase on the layout. Those words could be "just wrong" -- that is, just too low or high to be acceptable as a match or for the sample food item to be used. The most versatile pair of phrases is "I'd always choose this" and "I'd never choose it." Room must be made for an undistorted response to a sample that is worse than just unacceptable (Figure 1, right-hand side). In contrast, it is logically impossible to be better than perfect (unlike stronger than "extremely" intense or liked). This provision for responses worse than "just wrong" is also useful to check for the inclusion of a sample food that is personally unacceptable to any of the assessors -- a mistake that too often undermines the validity of sensory experiments on consumer products.

Contrary to persisting opinion, relevant descriptive analysis is readily feasible along with such assessments of degree of preference or overall mismatch to target (Booth, Thompson & Shahedian 1983; McBride & Booth 1986). The assessor simply states whether a named feature is above or below its "always choose" or "just right" point (Figure 1, right-hand side). Then each response can be plotted on the correct side of the peak point for any monitored factor that might influence that verbally characterised feature (Booth & Conner 1991).

## ***Analysis of Performance***

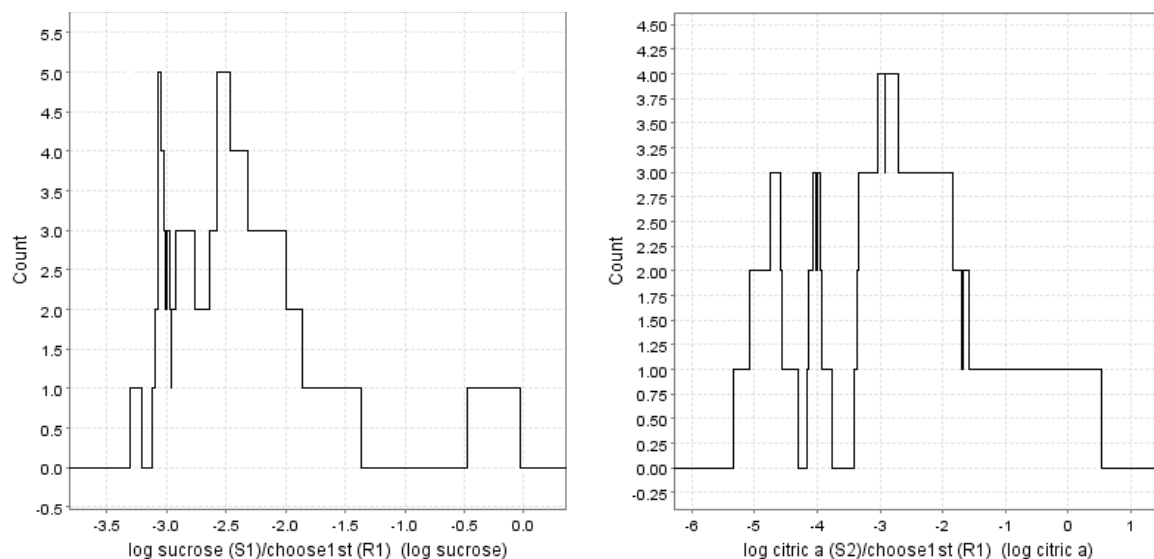
The strength of an influence on choice is the objective achieving of preferences that distinguish between levels of that influence. The smaller the disparity that affects a response, the stronger is that influence on the response. That is to say, fine discrimination is the same as strong causation. Hence all sensory and conceptual factors in food perception and choice can be put on the same theoretical mental scale of the number of discriminations from the norm point (standard level to be matched) that the assessor happens to be using. The panel response profiles presented in the rest of this paper plot each panellist's norm point at the middle of the range of one discrimination unit on either side. The narrower an assessor's norm range is, the more important is that feature in that person's overall choice, and the less is her or his tolerance for deviations from the norm point under

the conditions of testing.

The discrimination units and peak points for an individual's session are estimated by fitting the data to a conic section (hyperbola), as is implied by the peaked relationships of multiple factors to an overall closeness to matching the target (Booth & Freeman 1993; Booth, under review). The least squares regression used in this data-fit estimates the classic fractional increase in a factor's level which is halfway between perfectly discriminated and responding randomly, together with the point of equality between a level of the tested factor and the standard level in the norm (Booth and Conner 1991; Conner *et al.* 1986, 1988a,b; McBride and Booth 1986; Torgerson 1958).

Each assessor's norm point and discrimination unit for a tested factor in choice can be incorporated in an aggregate profile from the panel of assessors. The examples shown in this paper are histogram-like plots of personal discrimination ranges around "just right" levels. The plotting of these norm ranges dispenses with bins. Going from lower to higher levels of the factor on the horizontal axis (in the logarithmic units of discriminating between levels of sensed material characteristics), the count for an individual assessor starts with a vertical step upwards at one discrimination unit below the norm point and ends with a step downwards at one discrimination unit above. The surface of the profile is entirely based on each individual panellist's own performance, without any statistical assumptions that produce unrealistically smooth response profiles (and umbrella-like response surfaces for two factors).

## DISTRIBUTIONS OF IDEAL POINTS WITH DISCRIMINATIVE TOLERANCES



**Figure 2. Ideal range profiles for sucrose (left-hand graph) and citric acid (right-hand graph) in a vended orange-flavoured drink (N = 9). If the profile were of ideal points without the discriminative tolerance ranges, a suitable width of bin would show a smooth distribution that is near symmetrical. Using discrimination units to set the bin width for each panellist creates gaps in the distribution, around individuals who are highly discriminative. This is important information because a narrow discriminative range shows greater reliability in the estimate of the ideal point. (Histograms calculated from the raw data for Freeman 1996)**

## First Example: Drink Taste Compounds

The peaked calibration lines for multiple factors in individuals' perception and choice were first measured for mixtures of sugars and acids in a popular orange-flavoured drink (Freeman 1996). The tasted mixtures were kept tolerably over- or under-sweet or sour to each assessor, as well as equally often above and below the personally ideal level of the sugar in that drink, with the same procedure for the acid, in order to prevent well known biases in sensory ratings. This minimising of biases resulted in at least one level of each taste compound within each of the four ranges specified in Figure 1.

The observed profiles for assessors' ideal ranges for sucrose and for citric acid each approximated to Gaussian functions as well as can be expected for very small panels (Figure 2). Exceptionally, two or three normal distributions are seen in a profile of ideal points across a panel. This occurs when the assessors have been channelled by environmental-genetic interactions into acquiring different types of food choice habit. For example, those who eat highly sweetened packet foods and canned beverages show a profile of higher ideal points for a sweetener than do those who use fruit and sweet vegetables such as carrots for their snacks (Conner and Booth 1988; Conner *et al.* 1988b; Freeman *et al.* 1993). Another example is three normal distributions of ideal points for caffeine in coffee. These sensory segments presumably arise from non-tasters, tasters and supertasters at receptors for caffeine that overlap with those for 6-n-propylthiouracil (Booth, Sharpe and Conner 2011b).

It should be noted that the data on this orange drink show not only that the sourness of an acid is liked (at each individual's peak point) but also that the taste of sugar is disliked, increasingly so as the sugar level rises above one discrimination unit from the match to the personal peak for this drink.

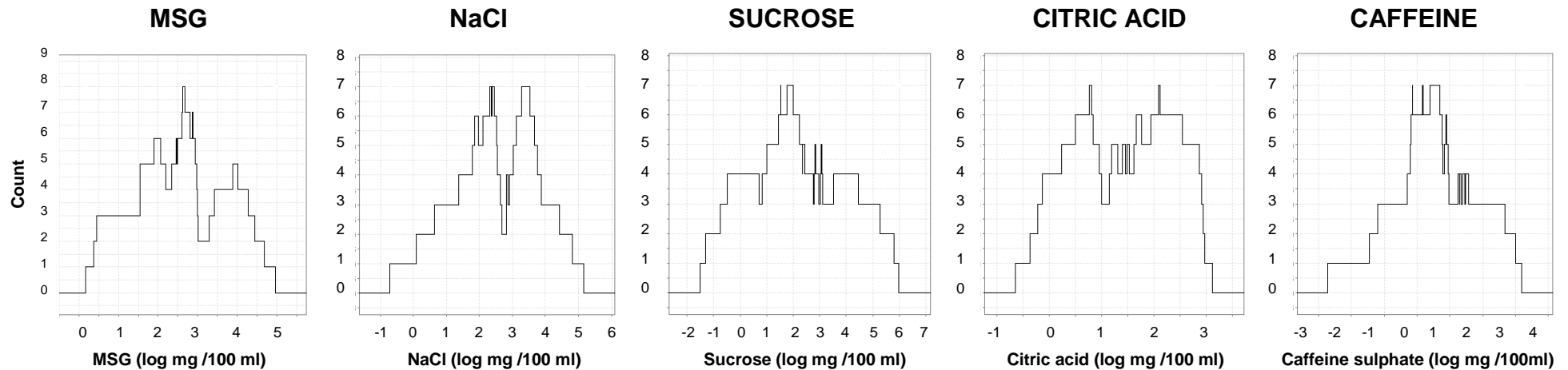
Ideal range profiles for as many as five taste compounds at once are equally feasible when the compounds are varied independently of each other in just eight samples per assessor of a familiar brand (Figure 3). However there was a low incidence of median matching points in this experiment because an automated algorithm has yet to be developed for real-time avoidance of stimulus biases with more than two or three factors being varied. Nevertheless, the assessors did not appear consistently in the lower or upper mode across the taste compounds. Hence the discriminative tolerances and most of the peaks are unlikely to have been affected by the slight difficulty in personal tailoring of the concentration ranges of five tastants simultaneously.

## Second Example: Dairy Emulsion Physics

We stay with basic scientific measurements of perception and action but turn now from chemistry to physics. Emulsions and colloids have two sorts of physical characteristic that may be sensed. On the one hand, there are the bulk parameters of viscosity (rheology) and friction (tribology). On the other hand is microstructure within the fluid.

The cream that separates from milk under gravity has oronasally sensed characteristics that are dominated by the aroma of the animal of origin and a variety of textural qualities. High viscosity can be conceived as thickness, albeit with complications from shear-thinning. Low friction may be encompassed by the term "slippery." One source of friction is adhesion to the surfaces in the mouth, describable as stickiness initially and as mouthcoating when that after-effect has had time to develop (Vingerhoeds *et al.* 2009).

### PANEL DISTRIBUTIONS OF PERSONAL BRAND-MATCHING POINTS WITH DISCRIMINATION RANGES FOR TASTANTS IN A SALTED TOMATO JUICE BEVERAGE



**Figure 3. Panel response profiles (frequency polygons) of individual assessors' ideal ranges for tastants in tomato juice: from left to right, monosodium glutamate, sodium chloride, sucrose, citric acid, caffeine. In order to visualise the distribution of the most reliably measured ideal points, sessions that showed very wide tolerance ranges have been omitted. The remaining widest tolerance determines the length of the horizontal axes of tastant levels. Gaps in a distribution can arise from sharp discriminations with precisely estimated matching points, rather than separating modes of matching point. A few assessors had consistently low ideal points across the five tastants. Another few had high ideal points for MSG, NaCl and citric acid. Concentrations are in the logarithm of mg per 100 ml, i.e. a  $\log_{10}$  level of 3 refers to 1% in grams. (Data summarised by Booth, Freeman, Konle *et al.*, 2011)**



A widely used term to complement thickness is “smooth.” Kokini (1987) claimed that the smoothness of dairy cream is its lubricating effect. This position has been revived in a powerful tribological model by van Aken (2010). However those proposals cannot account for the emergence of smoothness in dairy cream under specific microstructural and rheological conditions. When an emulsion with sufficiently high oil fraction and the natural dairy aroma and taste (from lactose and NaCl) is homogenised and then thickened using shear-thinning cellulose gum, a substantial rise in ratings of smoothness is seen (Richardson, Booth and Stanley 1993). One possibility is that the cream is squeezed to a monolayer of oil droplets between the tip of the tongue and the palate. Then the nerve endings in filiform papillae could send a signal to the brain about the sizes and spacings of those spherical particles at the papilla edges that are linearly arrayed on the tongue (Richardson *et al.* 1993). That neural pattern could be learned to be characteristic of dairy cream at the start of a mouthful and used as a personal norm in the assessment of smoothness of dairy cream.

In an industrial-academic collaboration, that microstructural proposal was tested on dairy flavoured emulsions in which mean size, inter-deciles range of sizes (span) and mean spacing between droplet centres, as well as viscosity, were varied independently of each other. Ratings of smoothness in some assessors were indeed driven primarily by discriminative tolerances for either low spacing or small span (Richardson and Booth 1993). That remained the finding when the theoretically possible interactions among sensed physical factors were calculated in later analyses (Booth 2005).

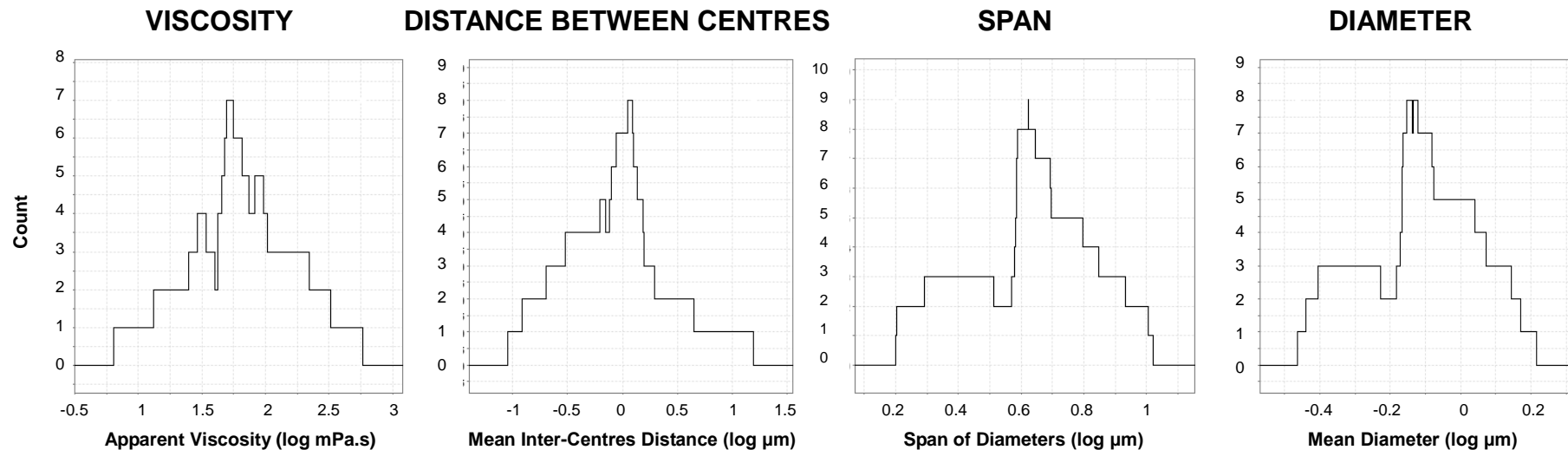
In a more recent academic project on public funds, the design was replicated and extended with more refined rheological analysis. The evidence once again was that most users of dairy cream recognise its smoothness from a narrow range of sizes of closely spaced fat droplets at a high enough viscosity (Figure 4).

The evidence for such perceptual achievements stands regardless of accounts of other physical processes within the mouth, and of what is known of the capacities of cortical processing of afferent patterns from sensory receptors. The findings cannot be gainsaid either by failures to observe effects of droplet sizes and spacings in experiments that have not varied them in the relevant ranges and contexts, nor tested their effects solely during the first wipe of the tongue on the palate. Such sensitivity to oil phase microstructure cannot be explained by the tribology of non-dairy emulsions between tongue and palate. Therefore slippery polysaccharides or other thickeners are no substitute for particles that are sized and spaced like the droplets in dairy cream.

### **Third Example: Instrumental Parameters**

Many important sensed material characteristics of foods are not reducible to basic physical or chemical measurements. This is most evident when the food is a mosaic of fundamentally distinct materials. Biscuits and other crisp baked goods are based on a matrix of starch mixed with protein that has lost most of the water in the uncooked dough. Discontinuities are created by sheets of fat and crystals of sugar. The texture of a biscuit is dominated by the cracking of the matrix when squeezed between the lower and upper teeth by partial closure of the jaw. The change in resistance to pressure from a crack is a physical measurement (in Newtons) but what produces that failure in the matrix is indeterminate at present. Therefore the only way forward is to obtain spatial or temporal profiles of force changes under pressure. These fracturing tests could be designed purely to understand the material. For a food, however, the most relevant fracture profiles are those generated and sensed by eaters of the tested biscuits.

## DISTRIBUTIONS OF INDIVIDUALS' DISCRIMINATION RANGES AROUND POINTS OF MATCH TO SINGLE CREAM



**Figure 4. Panel profile of physical values judged to match “single” (light) cream, plotted with discrimination ranges ( $n = 10$ ). Profiles from left to right: logarithms to the base ten of apparent viscosity (mPa.s) at shear rate of  $50\text{s}^{-1}$  (highly correlated across these test samples with low shear rate viscosity); mean distance between droplet centres ( $\mu\text{m}$ ); span of droplet diameters ( $\mu\text{m}$ , 10% to 90%); mean droplet diameter ( $\mu\text{m}$ ). The four physical measures were varied independently across the test samples of model dairy cream (flavoured with 100 mmol NaCl and the usual level of butterfat aroma). The differential sensitivity of some panellists to close spacing and evenness of size of the fat particles in the emulsion at the micrometre scale cannot be accounted for by frictional characteristics on a submillimetre level. (Unpublished data from follow-up to Richardson & Booth 1993 and Richardson *et al.* 1993, cp. Booth 2005)**

### ***Rigs to mimic use***

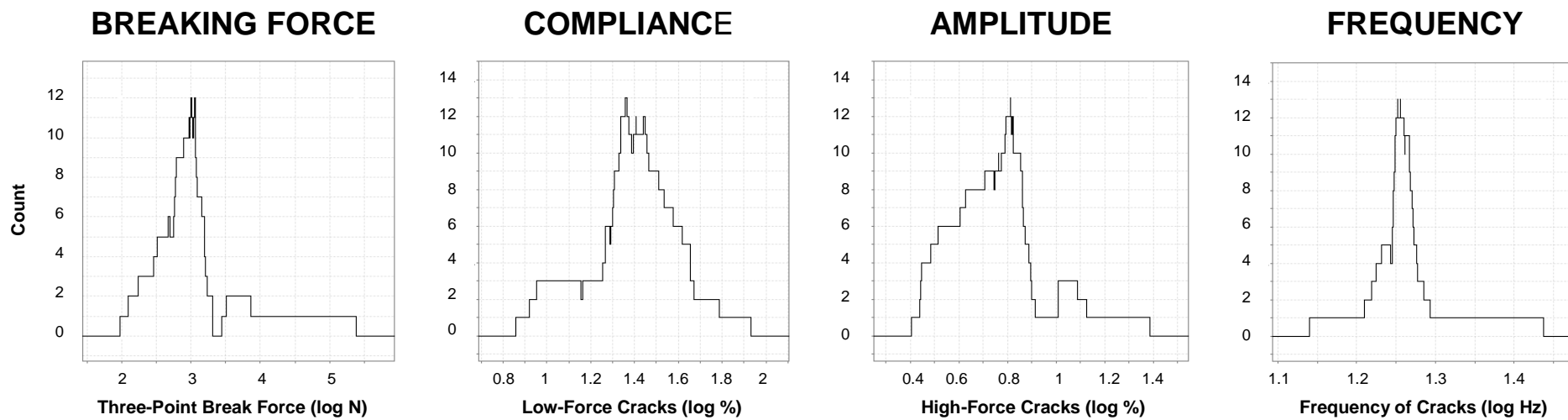
Biscuits are often too large to put into the mouth whole and so first a piece is broken off. Commonly a biscuit is broken by being held between the front teeth and perhaps the lips and levered downwards by the fingers (C.J. Wainwright and D.A. Booth, unpublished observations). The teeth may do most of the work but with assistance from flexing of the wrist. The force of complete fracture can be simulated fairly realistically by supporting the biscuit on two edges and bringing down between them a knife shaped like the front teeth and rigged into a force-measuring instrument (3-point break force, 3PBF). There is good consensus among consumers on the breaking force that they expect of a type of biscuit with which they are familiar (Figure 5). As expected, 3PBF predicted difficulty of snapping off a piece with the teeth (Booth *et al.* 2003a,b). Nevertheless 3PBF also contributed to how “crunchy” a biscuit was rated to be. This would be expected if strong cracking forces are part of crunchiness, as we see next.

Crushing the bitten-off piece between the molars is less easy to simulate. The mechanics become virtually impossible to analyse as the material becomes increasingly wetted by saliva. Even the first bite by the molars is greatly complicated by the accumulation of an increasing thickness of partly crushed material around an uncrushed remainder. The cleanest relevant force profile is from a needle which is sufficiently thin and sharply pointed enough to avoid such accumulation below the point of pressure (penetrometry). Once a fracture has appeared below the point of the needle, the forces of separation can be assumed to be negligible.

As in any real-life physics, the resulting oscillations of force are daunting to analyse. First the purpose of the analysis should be clarified. Relating amplitudes and frequencies to the structures that have cracked requires a quite different approach from relating them to sensed characteristics. Spectral power from Fourier analysis would capture all the data, but a more direct approach exploits what we know of the senses of hearing and touch that are both likely to be involved in perception of the texture generated by crushing a biscuit. The lowest amplitudes ( $< 0.05$  N), near the limit of the instrument's sensitivity, may be too small to be heard or felt. If so, they are unlikely to contribute to crunchiness and may be sensed as compliance to pressure from the teeth without cracking, i.e. slight denting of the surface (‘compliance’, Figure 5). Because the energy in a wave relates to the root mean square of the amplitude, the highest amplitudes ( $> 1$  N) were taken to represent effective overall amplitude. Omission of the intermediate range makes percentages of low and high amplitudes statistically independent.

In the event, high amplitude and average frequency of cracking made the strongest contributions to crunchiness, with breaking force presumably overlapping with high amplitude (Booth *et al.* 2003a,b). To the extent that crunchiness is heard, this corresponds to loud, high pitched noises (Vickers 1984). The instrumental specificity and precision of these findings contrasts with the vagueness of the dimensions produced by standard statistical methods of preference mapping (e.g., Kreger, Lee & Lee 2012 for crisp snack foods).

## PANEL PROFILES OF MATCH AND DISCRIMINATIVE TOLERANCE FOR INSTRUMENTAL MEASUREMENTS



**Figure 5. Distribution (n = 18) of point of match (with discriminative tolerance) to the standard short-dough biscuit on 3-point break force (left-most graph) and the three measures from penetrometry: percentages of low-force cracks, a surrogate for surface compliance (mid-left), and of high-force cracks (contributing most to root mean square amplitude: mid-right); and frequency of cracking (right-most graph). (Re-analysis of data reported by Booth *et al.*, 2003a,b)**

## Fourth Example: Processing and Formulation Variables

Too narrow a focus on developing vocabulary for each sensory modality obscures the value of measuring factors with effects across the senses that can be varied in the formulation and processing of a food (Moskowitz and Maier 2007a). Since the peak point is unlimited in number of implicit sensory dimensions, such physicochemically complex products can readily be handled by the present approach based on norm-zeroed discrimination scaling.

### *Recipes for biscuit crunchiness with less fat*

This fourth example comes from tests of potential ways of matching the crunchiness of short-dough biscuits without using so much fat. Very few sample variants are needed for a wide-ranging exploratory design in accord with the peak principle (Figures 2-5). Penetrometric measures (see the third Example) were used to select small sets of variants across which effects of formulation factors were minimally correlated.

For each varied factor, there was a single strong mode of counts of personally ideal discrimination ranges (Figure 6). This mode was robust. The highest counts of best discriminators (least tolerant, most strongly influenced) were mostly near the centre of the mode. Centred also on the most popular ideal points were the poor discriminators, i.e. those to whom the factor was least important in the objective sense of wide discrimination range, which means weak influence of the factor and great tolerance of deviation from the peak.

Modes of peak point for ingredients such as fat could be compared with the amounts in use in currently marketed products, although the profiles presented here are only to illustrate the principles. Some substitution by unsaturated fats could be acceptable overall, without any influence from a health-related declaration (Figure 6, Oil). Extra raising agent (ammonium bicarbonate in this illustration; Figure 6, third panel) could be of benefit to acceptance but the observed peak points put narrow limits on the amount to be used. The amount of water used was even more narrowly specified (note the  $\log_{10}$  % scale in Figure 6, Water), and as less than the contents of the tested samples (below 100%); this inference is by extrapolation because only extra water was tested. In contrast, there was a very broad range of highly tolerant preferences for the size of crystals of sugar (zero being  $\log_{10}$  of unity, representing the current size; Figure 6, far right-hand panel).

## Fifth Example: Conceptual Attributes

In a final example of discriminating from peak, we come to conceptual attributes of foods, as distinct from sensory characteristics. That is, the effective stimuli are symbols for ideas held in common by society, not simply stimulation of the senses by constituents of the materials. This contribution of a marketing concept to acceptance is sometimes called a utility or part-worth, as assessed for example by conjoint analysis (Green & Krieger 1991; the many recent uses include Foley *et al.* 2009, Gofman 2006, Schnettler *et al.* 2011). ‘Brand effects’ have been widely regarded as interfering factors in sensory analysis. Instead, scientific measurement of such interactions between production and marketing factors should be regarded as central to a food supplier’s service to the public and commercial self-interest.

The level of an explicit or implicit marketing factor for a food item is compared with its peak point by each individual assessor, just as a sensed factor is. Hence the panel counts of ideal points within ranges of discriminative tolerance are available equally for conceptual attributes and sensed characteristics.

## DISTRIBUTION OF DISCRIMINATIVE TOLERANCES OF OVERALL MATCH TO STANDARD BISCUIT

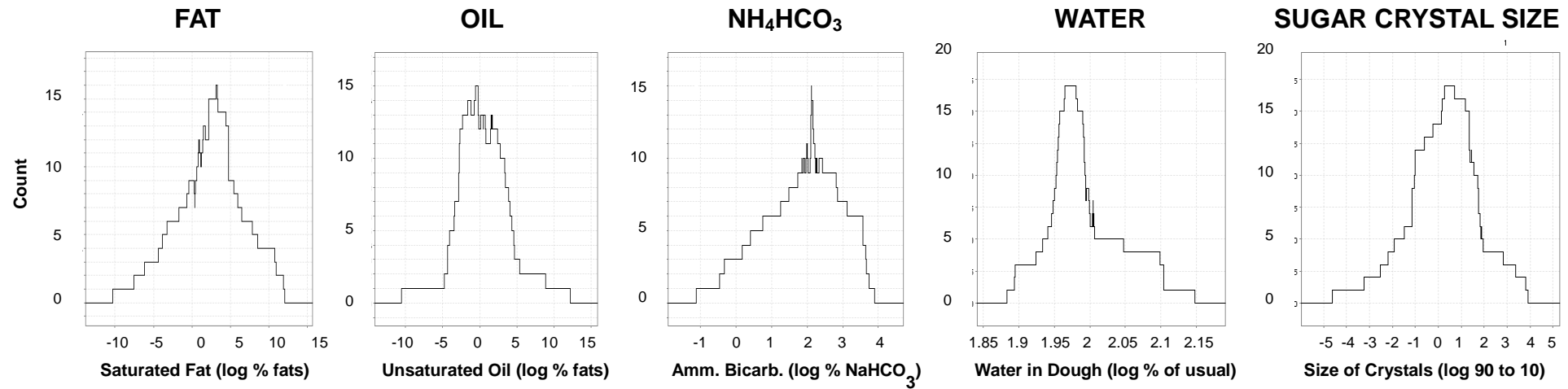


Figure 6. Panel profiles of individuals' "overall" matching points, with discriminative tolerance ranges, for shortbread biscuit ( $n = 21$ ). A narrow central tendency for an ingredient shows that the tested partial substitution for the usual fat (left-most panel) had some success in matching the overall texture at first bite. The usual size of sugar crystal was coded as 90, with smaller sizes ranging down to 10. (Unpublished data in follow-up to Booth *et al.* 2003a,b)

The first conceptual attributes to be discrimination scaled were fully explicit, in labels on the tested samples. A concept was combined with a sensed constituent in a fruit flavoured beverage. Either the label “low calorie sweetener” or the word “sugar” was placed on tasted samples that were varied independently in sucrose concentration (Booth & Freeman 1993; Freeman *et al.* 1993, Freeman & Booth 2010).

That industry-related project went on to vary the fat content label on samples of a spread covering a small piece of bread. The amount of spread was also varied, seen as thickness. A recent example of purely viewed foods also varied portion size and fat contents, with sugar content as a third factor (Chechlasz *et al.* 2009; Galea *et al.* 2008). In this case, there was no labelling and so the acceptance responses relied solely on assessors' identification of the food and the expected sensing, satisfaction after eating and long-term health in relation to believed fat and sugar contents, as indicated by regulated nutrient contents labelling that had been read in the past. The same large set of photographed food items was presented to each assessor (in a randomised sequence). Such procedures are almost certain to present assessors with some samples outside their personal range of acceptability. If the average distance from peak acceptance on some controlled or uncontrolled features is substantial, then the peak for each varied feature will be rounded to the extent of that contextual defect. The theoretical hyperbola that best fitted the raw data for a feature was indeed seriously eccentric in many assessors (e.g. Booth, Sharpe, Freeman and Conner 2011c). Yet, even with huge contextual defects and stimulus biases, it is still possible to estimate the point of match with “just right” that the individual used in the tested conditions, as well as tolerance of deviations from that peak. This contrasts with the statistical manoeuvre of running a theoretically empty quadratic regression through each assessor's data. In that approach, sometimes a trough can fit the data better than a peak, giving a meaningless 'anti-ideal' (e.g. Kreger *et al.* 2012).

Hence, a market concept can be conveyed without an explicit label. Equally, as noted at the start of this review, there is no need for a sensory descriptor in order to measure the influence of a sensed characteristic. If distance from “just right” is assessed without mention of sensory or marketing vocabulary, the norms in memory can still operate, even perhaps unconsciously (Booth and Conner 1991; Booth, Sharpe and Conner 2011a). Indeed, viewing the pictures of foods used in the recent experiment activates frontal regions of the brain that are deeply involved in the expectations that inform action (Chechlasz *et al.* 2009).

## Conclusions

The above examples show how straightforward it is to measure the influence of any sensed characteristic or conceptual attribute of an item of food on a person's perception of the item and on the act of accepting or rejecting it in the context of use. The measurements rely on the basic mental mechanism of discriminating between the level of a feature of the present situation and its peak level in a norm learnt from past situations (Booth and Freeman, 1993; Booth *et al.* 2011c). The trained or untrained assessor's response to a test is proportional to these conscious or unconscious disparities between the present and the past, as they are configured in the personal norm.

Hence, when the levels of any sensory or symbolic factor have been monitored across the test samples, an assessor's peak point of that factor in the personal ideal or a familiar target product or brand follows directly from the observations, together with tolerance for disparities from “just right.” Aggregation of peak points and discriminative tolerances across a representative panel gives

an equally direct estimate of the market for each variant of the product in the uses that are simulated by the testing (Figures 2 to 6).

### ***Advance from numbers to facts***

All acquisition and analysis of human data needs to include peak-referenced responses and hypothesis-testing designs. Because everybody's mind operates in this way, such questions and answers are easier to operate on malls, over the internet or in the laboratory than tick boxes on series of vague and puzzling phrases, or unnecessarily difficult tasks such as ranking, voting or identifying the odd one out. Sufficient for most purposes are two precise anchor phrases, such as “just right” and “just wrong” (with “worse” beyond), on an array of otherwise unlabelled boxes, or of integers from a zero on one of the two anchor phrases (Figure 1). What matters for the science, technology and marketing are the causal relations of those scores to the peak points and limits of tolerance for each of the factors that are varied among sets of realistic food samples.

Statistical modelling of response numbers cannot measure optimum levels of the real factors that are under the control of production and marketing. Indeed, sensory profiling scores are not even necessary to measure the effects of sensed factors on consumers' choices. Attitude models, like/dislike category ranks, pleasantness line ratings and hall preference votes, also fail to make contact with actual influences from purchased products.

It is irrelevant whether or not the consumer experiences a sensation or a pleasure when rating intensity or preference. S/he might instead be using the sensory vocabulary or the term “like” or “pleasant” to categorise the test item on a series of familiar foods having greater or less intensity or likelihood of being chosen. An eater or a shopper may be following a habit or an impulse without any awareness of what is influencing the choice of item. Each of these psychological hypotheses can be refuted or confirmed by the scaling of discrimination distances from the personal norm being used during the tests (Booth and Conner, 1991; Booth and Freeman 1993; Booth *et al.* 2011b; Booth *et al.* 1983).

A psychological science and technology of food has long been accessible within the facilities and costs already dedicated to the collection of human responses (Figure 1). In psychology at least, the most basic scientific findings about familiar situations are also the most practically relevant (Figures 2 to 6).

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